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# The Impact of the U.S. Army's AH-64 Helmet Mounted Display on Future Aviation Helmet Design

## (Reprint)

By

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August 1988



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with the aircraft systems. The development and fielding of the IHADSS helmet mounted display have expanded the role and importance of the helmet. If helmet mounted displays are the design choice of future aircraft, it will be imperative to place increased emphasis on the human factors aspects of the helmet.

# THE IMPACT OF THE U.S. ARMY'S AH-64 HELMET MOUNTED DISPLAY ON FUTURE AVIATION HELMET DESIGN

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## ABSTRACT

Historically, the goal of aviation helmet design has been to provide primarily impact and noise protection to the user. In 1985, the U.S. Army fielded an advanced attack helicopter which required a new helmet concept in which the role of the helmet was expanded to provide a visually coupled interface between the aviator and the aircraft. This new helmet system, the Integrated Helmet and Display Sighting System (IHADSS), uses a helmet fitted with an electro-optical head tracker and a monocular display. The head tracker allows a slewable thermal imaging sensor, mounted on the nose of the aircraft, to be slaved to the aviator's head movements. Imagery from this sensor is presented to the aviator through the helmet-mounted display (HMD). This type of system generated several concerns, recognized early on, but which still are unresolved. These areas include questions of monocular vs. binocular imagery, eye dominance, and binocular rivalry. In addition, the task of interfacing the aviator's head to the aircraft has introduced previously unanticipated problems relating to head anthropometry and facial anatomy. The fitting process has become a crucial factor in the aviator's ability to interface with the aircraft systems. The development and fielding of the IHADSS helmet-mounted display have expanded the role and importance of the helmet. If helmet-mounted displays are the design choice of future aircraft, it will be imperative to place increased emphasis on the human factors aspects of the helmet and the display.

## INTRODUCTION

The basic definition of a helmet is an armored device designed to protect the head. The use of helmets can be traced back to the ancient Egyptians and Assyrians. These first helmets, constructed from fabric or leather, were used to protect against clubs and lances (Ferguson, 1981). Numerous helmet styles were introduced for use up through the 17th century. With the introduction of firearms, helmets and other personal armor fell into disuse. It was not until World War I, with the development of fragmentation armament, that helmets again were recognized as a necessary piece of protective equipment. In the decades to follow, improvements in manufacturing processes, discovery of newer and better protective and energy-absorbing materials, and extensive ballistic research have led us to the modern military helmet. While the design of the basic helmet changed throughout history, the primary purpose of the helmet has remained that of impact protection.

APPENDIX III TO ANNEX M

The use of helmets in aviation, and more specifically in U.S. Army aviation, covers a much shorter span. U.S. Army Aviation, officially born on June 6, 1942 via a doctrine of ground support/air assault, can be considered conceived in September 1861 when the Union Army sent hot air balloons aloft for the purpose of observation of Confederate troop movements. The first "heavier-than-air" flight machines were delivered to the Army in August 1909.

Based on records and preserved examples from early Army aviators, the first helmets were fabricated from leather and fabric. Their purpose for the most part was protection from the elements. However, it was not uncommon for some aviators to wear industrial-style hard shelled helmets, obviously for impact protection. The need for impact protection was recognized early by aviators, as well as other aviation personnel. An accident investigation of a 1913 crash involving two U.S. Army Signal Corps pilots concluded that one of the men escaped serious injury due to the presence of his helmet, his head having received multiple high energy blows (U.S. Army Board for Aviation Accident Research, 1962).

Even as late as the 1950s, the Army did not have an aviator's helmet of its own. However, many Army pilots wore helmets belonging to the other services, e.g., the Navy M-4 and the Air Force P-3. The first aviator's helmet officially adopted by the U.S. Army was the U.S. Navy Aircrewman's Protective Helmet (APH-5) and was first issued in October 1959. Available in three sizes, individual fit was accomplished by means of a set of six different replaceable sponge rubber pads. The helmets possessed adjustable earcups and a single visor housing. The only modification required for Army use was the replacement of the electronics jack-plug. The APH-5 had a weight of between 3-4 pounds.

In the late 1960s, an Army developed helmet, the Aircrewman's Fragmentation Helmet (AFH-1) saw brief use during the Vietnam conflict. It was overwhelmingly rejected by the pilot community. The small-sized version weighed slightly over 3 pounds; the extra-large sized weighed over 5 pounds and literally was as large as a half-bushel basket. It was not until 1970 that the Army finally introduced the current Army aviation helmet, the Sound Protective Helmet (SPH-4), an improved version of the U.S. Navy SPH-3.

In retrospect, we can see that from 1861 to the 1970s, the role of the helmet in aviation expanded to include additional protection for hearing and to serve as a vehicle for communication accessories, e.g., microphone and earphones. Even further expansion of the role of helmets in aviation occurred in 1971 when the Department of the Army adopted night vision devices for use in aviation. These devices, designed to enhance the aviator's capability to operate during periods of low illumination, were mounted on the helmet via straps. Since then, the Army's doctrine of being able to carry out missions in total darkness and under all weather conditions has resulted in the research and development of more advanced helmet-mounted night vision systems. These systems are designed to present flight imagery and information. There is a military need to provide the pilot with a tremendous array of flight data. The helmet-mounted display (HMD) provides a method of presenting this data without worsening the problems of an already crowded cockpit. The most prominent example of this effort is found in the U.S. Army's Advanced Attack Helicopter (AH-64), fielded in 1985. In this aircraft, a new helmet concept was used which dramatically altered the role of the helmet. This new helmet system is known as the Integrated Helmet and Display Sighting System (IHADSS).

## THE INTEGRATED HELMET AND DISPLAY SIGHTING SYSTEM

The IHADSS was developed specifically for the AH-64 attack helicopter. This system is designed around a helmet referred to as the Integrated Helmet Unit (IHU), see Figure 1. Along with various electronic boxes, the following components are included: visors (clear and tinted), visor housing, monocular optical relay unit (known as the Helmet Display Unit (HDU)), miniature cathode-ray-tube (CRT), and communication and video cables. The function of the helmet-mounted display components of the IHADSS is to provide night vision information to the pilot for the purpose of nap-of-the-earth (NOE) pilotage, target acquisition and identification, weapons aiming, and to provide daytime symbology (Walker, 1980).

In the basic operation of the IHADSS, an electronic image of the external scene, formed by a thermal imaging sensor mounted on the nose of the aircraft, is converted into a light image on the face of the CRT. This image is relayed optically through the HDU and reflected off a beamsplitter, also known as a combiner, into the pilot's eye. Therefore, it is through the HDU that the pilot receives his primary visual data to fly the aircraft. Infrared detectors mounted in the IHU allow the aircraft's imaging sensor to be slaved to the pilot's head movements. Aircraft parameter symbology, along with the sensor video, is presented to the pilot by means of the HDU. In addition, target acquisition and weapons information also can be displayed. The display system is designed so the image of the 30 degree vertical by 40 degree horizontal field-of-view (FOV) of the sensor subtends a 30- by 40-degree field at the pilot's eye. This provides an imaging system of unity magnification. This field-of-view is controlled by the pilot's line-of-sight and has a field of regard of +/-90 degrees in azimuth and +40 to -70 degrees in elevation.

The IHU is custom fitted with pads to provide a stable platform for the HDU. The display has a 10 mm exit pupil in order to provide for some eye position tolerance.

The IHADSS represents a tremendous transition in helmet sophistication. The IHU in the IHADSS plays a crucial role of linking the pilot and the aircraft. Aviator performance and safety are dependent highly on the transfer of the sensor information to the eye through the HDU. With the advent of the IHADSS helmet, Army aviation has moved from an era of the "slap-on, cinch-up" helmet to one where the helmet is a precision-tuned piece of equipment, requiring special considerations and care. The purpose of this helmet extends beyond that of protection, to include providing a platform for presentation of flight imagery and weapons delivery information.

## ISSUES AND CONCERNS: PAST AND PRESENT

Serious interest in helmet-mounted displays began in the 1960s. One of the first reviews of HMD issues and problems was conducted by Miller in 1969. Potential problems included: switching from a daylight system to a night system, retinal rivalry, reflections, weight, and pilot acceptance. In 1973, a follow-up overview of known and potential HMD problems was conducted by Hughes et al. In their report, retinal rivalry remained the major issue with brightness disparity, center-of-gravity, field-of-view, exit pupil, and eye dominance added to the list. It was against this background that the U.S. Army began the IHADSS program for the AH-64 attack helicopter in the late 1970s.

Honeywell, Inc., the developer of the IHADSS, identified two technical areas of concern during the early design phase (Walker, Verona, and Brindle, 1980). The first involved the mechanics and human factors of interfacing the HDU and the aviator. The second concern was the quality of the imagery to be presented on the display.

For optimum transfer of information from the HDU to the pilot, efforts had to be directed towards problems associated with placing the collimated image in the user's eye with good registration, stability, and user acceptance. Such factors as weight, center of gravity (CG), exit pupil, field-of-view, and vibration had to be solved.

Equally important to optimize the transfer of information was the quality of the image presented on the HDU. Problems associated with providing sufficiently high brightness and contrast had to be addressed. Besides the need to achieve high optical transfer functions for the relay optics, the design of output characteristics of the CRT was critical.

The production IHADSS helmet advances greatly the role of aviation helmets. In addition to providing the traditional impact and acoustical protection and communication capability, it serves as a platform for the presentation of night vision imagery, day/night flight symbology, and weapons delivery information. All this is accomplished in a 4-pound (head-supported weight) helmet. However, despite this engineering feat, the fielding of the IHADSS helmet was an educational experience for the Army and the helmet-mounted display community. Many old problems have been solved, some only to a relative extent, and many new problems have been identified.

The following discussions address major aspects of the design, development, and fielding of the IHADSS which have impacted and will continue to impact future aviation helmet designs.

## Weight

The effects of placing additional weight on the aviator's head generally can be grouped into two areas: fatigue and crash dynamics. Very little research has been done to document the fatigue factor associated with increased head-supported weight. The brief experience with the AFH-1 during the late 1960s revealed that a weight of over 5 pounds is not user acceptable. One study, conducted in 1968 by the U. S. Army Human Engineering Laboratory, found that a total head-supported weight in excess of 5.3 pounds (2.4 kg) degraded the performance of complex sighting tasks. This degradation manifested itself in slower head motions, most likely the result of muscle strain. Fatigue in the head and neck muscles can slow reaction times associated with movements of these muscle groups. In situations where the primary pilotage imagery input is controlled by head movement, this slowed reaction time could create a dangerous condition and also may contribute to decreased maneuvering accuracy. In addition, the resulting fatigue may create a lethargic attitude. However, the quantitative relationship between weight and performance degradation has not been documented.

The effect of increased head-supported weight in crash dynamics is a direct result of the additional mass. For the 50th-percentile male, the head and neck weight is 11.7 pounds (5.3 kg). In the worst case for current HMD configurations, an additional 6.7 pounds (3.0 kg) (for AN/PVS-5 NVG with 1.4 lb counterweight on SPH-4 helmet) results in a 57 percent increase in head-supported weight and accompanying G-force in a crash. This increased G-loading further will contribute to head and neck muscle fatigue during maneuvers of low to moderate accelerations (< 5G). However, of most concern is the additional amount of G-force which will act during crashes, even though all current HMDs are designed to break away at specific G-levels.

The IHADSS has a head-supported weight of 4.0 pounds (1.8 kg) for the large-size helmet and 4.1 pounds (1.9 kg) for the extra-large. When compared to the typical 6.7 pounds (3.0 kg) for the AN/PVS-5 (with counterweight), these values represent a significant reduction in weight. Interviews with AH-64 pilots seem to indicate that a weight of 4.0 pounds (1.8 kg) is user acceptable.

While current data does not provide a definitive maximum weight limit, and operational tradeoffs to ensure mission success must be recognized, common sense should dictate that minimal weight must be a goal in helmet design. Current guidance for future helmets states that the basic helmet structure should not exceed 2.85 pounds (1.3 kg) and that the typical operational weight should not exceed 4.0 pounds (1.8 kg). It will be difficult for future designs to move from a monocular to biocular or binocular display and still meet the weight guidelines.

Center of gravity

Until helmet-mounted displays and other components were required to be placed on the helmet, the helmets essentially were balanced on the head producing relatively high stability as long as proper fit was achieved. With the presence of the HMDs, there is a resultant shift in the CG of the helmet system. The center of gravity for the IHADSS large helmet (with display in position) lies forward and to the right of the head/neck CG (0.8 inches (2.0 cm) forward, 0.75 inches (1.9 cm) to the right, and 1.06 inches (2.7 cm) upward).

Since it is the torque (product of the helmet weight and the lever arm formed by the displaced CG) which produces the resulting muscle strain and fatigue, the helmet weight and CG must be considered together. However, pilots have demonstrated by the addition of counterweights that CG shifts are less tolerable than increased weight. This places the typical head-supported weight for the SPH-4 helmet with night vision goggles and maximum counterweight at 6.7 pounds (3.0 kg).

Unfortunately, data to define limits in CG shifts have been contradictory. Current thinking depicts vertical CG shift as more acceptable than forward and lateral shifts.

Anthropometry and fit

In order to perform all necessary flight procedures from information presented on the helmet-mounted display, it is crucial that the helmet platform be stable and provide a consistent fit from flight to flight. Helmets incorporating HMDs require more attention to the quality of fit. Lessons learned from establishing a fitting program for the IHADSS will be instrumental in the successful fielding of future systems.

Problems encountered in the fitting program fall in two broad categories: anthropometry and fitting skills. The stability required to acquire and maintain the optical interface between the pilot's eye and the display optics requires individual shaping of the helmet interior to the pilot's head anatomy. The procedures necessary to accomplish this require a trained fitter, special tools and devices, and properly orientated pilots.

The head and facial anatomy of the pilot were discovered to be crucial to the ability to provide a proper, stable fit and display interface (Rash et al., 1987). Not only were there problems associated with one or more extreme head dimensions, but there were additional problems related to head abnormalities, e.g., one ear lower than the other, tapering forehead, bulges, etc. All of these variations increased the detailed attention required to provide a comfortable and stable fit.

Facial anatomy features, such as a protruding cheekbone or deeply set eyes, can affect the use of the display by preventing the positioning of the display's exit pupil close enough to the pilot's eye. This problem results in a decreased field-of-view similar to the "knothole effect."

It will be necessary for future helmet designs to attempt to reduce the impact of head and facial anatomy on the time and effort needed to achieve a stable fit. The need to quickly and easily provide a helmet interior which will comfortably ensure a contoured fit must be met. Considerable progress already has been made with the development of the Thermoplastic Liner (TPL).

The most important lesson learned from the establishment of the fitting program is the importance of the role of the helmet fitter. As with most tasks, the fitting of the IHADSS helmet requires some minimum skill levels on the part of the individual performing the task. Because of the sophistication of this helmet, the characteristics of a "qualified" fitter preclude the often adopted philosophy of listing the fitting task as "other duties as assigned." The experience with IHADSS has made it apparent that the designated fitter must possess reasonable technical and mechanical skills. These are required to perform the necessary adjustments and modifications to obtain a proper fit.

Along with ability, the fitter requires considerable training in order to perform the numerous tasks involved in the fitting process. The IHADSS fitting procedure consists of eight basic steps: head measurement, data recording and documentation, pilot education, contouring of suspension assembly and earcups, helmet reassembly, HDU optical alignment and field-of-view measurement, boresight verification, and visor trimming. The total time to complete a fitting typically is 2 hours. The use of a web suspension system over the sling suspension of the SPH-4 contributes to this considerably longer fitting time. However, the web suspension provides much greater stability.

Perhaps the most important step in the fitting procedure is the education of the pilot concerning the importance of the optical alignment to his performance in the aircraft. This requires more than a minimum level of communication skill on the part of the fitter.

An evaluation of the IHADSS fitting program was conducted after the first year of fielding of the AH-64 (Rash et al., 1987). Critical points required to establish and maintain a successful fitting program for helmets utilizing helmet-mounted displays were identified. They include the following: (a) designate the fitting task as a primary responsibility of the fitter, (b) provide a formal training program, (c) place command emphasis on the importance of a quality fit, (d) provide sufficient number of fitters and fitting equipment kits, (e) provide aviators with orientation to helmet prior to fitting session, (f) utilize actual display unit during alignment and field-of-view verification, and (g) establish a central facility for fitting control.

Field-of-view, exit pupil and eye relief

The IHADSS was designed to provide a 30-degree vertical by 40-degree horizontal field-of-view. It has a 10 mm exit pupil vignetted 20 percent at full field. The eye relief from the center of the beamsplitter is 33 mm. The three parameters of FOV, exit pupil, and eye relief are interdependent for a given optical system. Increasing available eye relief decreases the potential FOV. Likewise, increasing the exit pupil also will decrease FOV. For the IHADSS design, FOV was maximized at the expense of eye relief and exit pupil size.

Eye relief is important in providing compatibility with spectacles and chemical protective masks. The standard configuration for wearing the IHADSS requires the barrel of the HDU to rest against the cheek. The placement of any additional device between the eye and the HDU forces the HDU out from the eye, adversely affecting the available FOV. In the case of the IHADSS, the 33 mm optical eye relief, as measured from the beamsplitter, is decreased by the physical presence of the barrel of the HDU. The resulting "physical" eye relief distance is effectively zero. This distance is compromised further by facial features for some pilots. Indeed, some AH-64 pilots are unable to achieve the 30 x 40 field-of-view due to decreased physical eye relief resulting from protruding cheekbones or deeply set eyes. The introduction of the M-43 chemical protective mask (Figure 2), designed specifically for the IHADSS, has been found to reduce the FOV along a given meridian by approximately 12 percent (Rash and Martin, 1987). Future optical designs must provide adequate "physical" eye relief to prevent major compatibility problems.

In order to view the imagery, the pilot must be able to maintain the entrance pupil of his eye in the exit pupil of the system. This task is made more difficult by aircraft vibration, helmet misalignment, and head and eye movements. Proper sizing of the exit pupil allows eye excursions without noticeable vignetting (dimming) of the display. Without these complications, the 10 mm exit pupil for the IHADSS would be adequate. However, in practice, the current exit pupil size has been a minor problem. If exit pupil size is to be sacrificed for field-of-view and eye relief, the stability of the helmet takes on even greater importance.

Field-of-view was a dominating design parameter for the IHADSS. The sensor used to provide the input signal has a FOV of 30 x 40 degrees. It is desirable for the display imagery to subtend angles at the eye equal to the FOV of the sensor, thereby providing a one-to-one relationship with the outside scene.

The question of how large a field-of-view a helmet-mounted display must provide still is unresolved. One complication is that FOV and an equally important parameter, resolution, are inversely related. Therefore, the question really is, "What tradeoff of FOV and resolution is acceptable?"

Factors which influence the answer to this question include anticipated missions, airspeed, spatial and/or thermal characteristics of terrain, altitude, workload, environmental conditions, and sensor characteristics. More often than not, the desired ranges for these factors are more wishful thinking than realism.

Monocular imagery presentation

The IHADSS is a monocular display system, the display imagery being presented to a single eye. This information presentation method is contrary to our normal visual system and to our experience with night vision goggles, both of which are binocular. A third possible choice of presentation is biocular, where the same imagery from a common sensor is presented to both eyes.

The question of a monocular versus a binocular/biocular display for the IHADSS was addressed during the early stages of the AH-64 program. Based on technology and the various trade-offs, a decision for a monocular display was made. The main advantages of a monocular HMD are: weight savings, reduction in alignment adjustment hardware, less cost, less display controls, and simplified emergency egress procedures. The disadvantages are: retinal rivalry, lack of redundancy, and slight decrease in visual resolution, contrast, and field-of-view sensitivity (McLean and Smith, 1987).

The decision for a monocular HMD design faced two major problem areas: eye dominance and retinal rivalry. Eye dominance is the preference to use one eye over the other during certain visual tasks. Retinal rivalry manifests itself in the inability to selectively switch attention back and forth between two different imagery inputs being presented to separate eyes. The eye dominance problem could have influence on the structure of the helmet, training, and perhaps pilot selection. A presence of retinal rivalry to a significant degree could have precluded totally a monocular HMD design.

From an engineering position the IHADSS Helmet Display Unit could have been placed on either side of the helmet, making eye dominance a moot point. However, throughout the program, weight was a major concern, and being able to restrict the mounting of the HDU to a single side would save precious grams. Although numerous tests exist for measuring eye dominance, a study conducted by McLean in 1983 failed to show good correlation between the results of these tests. In his study, 16 individuals, selected as potential AH-64 pilots, were measured for eye dominance using 8 different tests and tracked during their training period. In addition to the lack of correlation of results between tests, the small sample size and uncontrollable factors associated with AH-64 training precluded finding any valid correlation between eye dominance and time required by the subjects to qualify with the IHADSS.

In the IHADSS, the right eye is presented with the imagery from the helmet-mounted display's CRT. The left eye is presented with the naked eye imagery of the internal cockpit and/or external environment. In retinal rivalry both scenes may be seen, but usually one scene will be totally or partially suppressed, while the other scene dominates. Which image is suppressed depends on parameter values associated with the two disparate scenes. These parameters include luminance, motion, scene complexity, focal plane differences, and interocular threshold differences.

At night, the pilot wishes to be attentive of the CRT imagery, since this provides the thermal imaging sensor pilotage input. On dark nights, use of the left eye is limited to some internal cockpit viewing of instruments and attention to bright lights outside the cockpit. However, on nights of high lunar illumination, pilots tend to rely equally on imagery from both eyes to perform close quarters maneuvers. In the daytime, pilotage is accomplished by the unaided left eye, but the HDU is often used to provide heads-up symbology. Therefore, at night, with the high luminance, complex imagery provided to the right eye through the HDU, problems associated with retinal rivalry are a function of external illumination. However, in daytime, when the pilot may consistently switch between the external scene and the symbology, this phenomenon may be present. AH-64 pilots have reportedly developed unique techniques for overcoming any switching problems which occur.

Briefings held with AH-64 instructor pilots seem to indicate that retinal rivalry is not a major problem for experienced AH-64 IHADSS pilots. However, it is well known that learning to fly the monocular IHADSS is a demanding visual task. AH-64 student pilots demonstrate a considerable range in number of training hours required to acquire competency with the system. This spread may, or may not, be associated with the use of the monocular display. In practice, once the system is mastered, most AH-64 pilots voice a preference for future helmet-mounted displays to be monocular. However, this preference probably is based on the desire not to give up the ability to view internal cockpit instruments with the display in place rather than an actual preference of monocular over binocular displays. Future HMD designs currently are planned to be binocular or biocular.

Field maintenance

Because the helmet now is packed with electronics and serves as a platform for an optically aligned display and weapons system, it must be handled and maintained in a more controlled manner. Obviously, the helmet, being a piece of military equipment and intended for use in a hostile environment, must not be so delicate that it will become inoperable with normal wear and tear. However, sophisticated equipment does require more careful handling which can be achieved only through pilot education. One problem is storage of the helmet system when not in use. Automobile trunks and household closets will no longer serve as acceptable storage for the newer helmets.

A formal field maintenance program is essential for the fielding of sophisticated helmets. Periodic checks of critical components and alignments are required to prevent performance degradations. Maintenance personnel should be the same personnel trained in the fitting of the helmet, since the maintenance of a proper fit is itself crucial to performance.

User acceptance

Regrettably, user acceptance has defeated some of the best designed components. If the user fails to use the designed item properly, or not at all, its functions may be degraded, or even made useless. User acceptance depends on several major areas: appearance, purpose, and comfort.

Utilization based on appearance has no logical place on the battlefield. However, since most equipment currently sees more training time than combat time, image perception often overcomes common sense. The IHADSS helmet has a somewhat bulky appearance, but this has not been a factor in its acceptance. This is because wearing the helmet is an operational requirement for interfacing with the communications, pilotage imaging, and weapons delivery systems of the AH-64.

The question of comfort is an individual decision. Thresholds for discomfort and pain vary greatly. Inability to provide a comfortable helmet fit will affect negatively a pilot's performance. With the IHADSS helmet, comfort depends on a properly-sized helmet, achievement of stability, and equalization of pressure at all contact points.

The IHADSS helmet, required to fit 1st through 99th male percentiles, initially was built to anthropometry data gathered in 1970 (U.S. Army Natick Laboratories, 1971). During acceptance testing, complaints arose concerning extremely tight helmet fits. Consequently, a survey of 500 U.S. Army aviators was conducted and it was determined that head dimensions had increased significantly during the decade of the AH-64 development. This sizing problem was compounded further by the decision to use an under-the-helmet chemical protective mask. As a result, a program to develop an extra-large sized helmet was established in 1985, and the size problem was solved when the first extra-large helmets were fielded in early 1987.

Of the 2 hours required to custom fit the IHADSS helmet, the greatest amount of time is dedicated to contouring the helmet's interior. The comfort of the fit depends on the fitter's ability to achieve an equal distribution of pressure over the area of contact. Even after this somewhat lengthy fitting period, adjustments are required later to compensate for "wear in." Unfortunately, many pilots attempt to make self-adjustments. This often results in an ill-fitting and uncomfortable helmet.

One other comfort problem encountered and corrected early during the IHADSS fielding was the positioning of the chinstrap component of the retention system. The designed method of attaching the chinstrap to the helmet exerted excessive force rearward in the neck region of the "Adam's apple." This was corrected by repositioning the rear and front yoke straps.

## FUTURE AVIATION HELMET DESIGN

Presently, two aviation helmet development programs are being pursued by the U.S. Army. They are the Aircrew Integrated Helmet System (AIHS) program and the Helmet Integrated Display Sighting System (HIDSS) program. The helmet being developed under the AIHS program is known as Head Gear Unit-56/P (HGU-56/P). The HIDSS program is in support of the Light Helicopter Experimental (LHX) program.

### Aircrew Integrated Helmet System (AIHS)

The HGU-56/P helmet has arisen from the recognized need for an aircrew helmet which can provide nuclear, biological, chemical (NBC), and directed energy protection and be compatible fully with displays and life support devices. Continuing advances in fire control, display, and armament technologies, coupled with dynamic requirements for NBC and directed energy threats, have resulted in a need for a large number of helmet configurations. To address the needs of the future integrated battlefield, but without a proliferation of helmets, the AIHS helmet has been developed (Aviation Life Support Equipment Product Manager, 1987). This system will replace the current standard aviator's helmet and will be utilized in all U.S. Army rotary-wing aircraft, with the exception of the AH-64. Its projected fielding is scheduled for 1992.

The primary functions of the AIHS are to provide head, acoustic, eye, and respiratory protection. By adopting a modular approach, various system configurations will provide these and other specific capabilities. These include: advanced fire control sighting systems, pilot night vision systems, NBC protection, directed energy protection, and nuclear flash protection.

The AIHS is required to provide equal or greater levels of impact and acoustical protection and more capabilities when compared to the IHADSS. With its modular approach, these will be accomplished with decreased head-supported weights. The display to be used on the AIHS helmet will be the advanced version of the IHADSS helmet display unit. This "advanced HDU" provides an improved physical eye relief which will assist in overcoming the negative impact on field-of-view resulting from differences in facial anatomy and compatibility with NBC masks, corrective lenses, etc.

Helmet Integrated Display Sighting System (HIDSS)

The LHX program was initiated to replace the U.S. Army's current, but aging, helicopter fleet. While still in its initial planning phase, current plans call for a combination scout/attack aircraft. A major effort under this plan is a risk reduction program, the purpose of which is to demonstrate the advanced technology needed to accomplish the stated requirements for this future helicopter concept. One part of the risk reduction program addresses the development of an advanced design helmet-mounted display, the HIDSS.

For the proposed LHX helmet-mounted display, the IHADSS requirements have been modified to provide increased performance and capabilities. The expanded requirements include a larger field-of-view (initially 2400 square degrees, currently 1800), binocular presentation, and laser and flashblindness protection; all of which are to be accomplished within a 4.0 pound head-supported weight limit.

Currently, two teams of contractors are participating in parallel investigations of advanced HMD systems. The major goal for these investigations is the validation of the technologies needed to develop a wide field-of-view binocular/biocular integrated helmet system which will also meet the strict protection requirements and be within the established weight constraint. At least a decade or more away from fielding, this aircraft will most likely represent another tremendous advance in helmet-mounted display systems.

## SUMMARY

Aviation has placed a tremendous demand on the basic helmet. Its original purpose of weather and impact protection now is greatly expanded to include serving as a platform for a communication system and for displays and weapons delivery systems. After a decade of development and 3 years of fielding, the IHADSS, as the first production integrated helmet-mounted display, has demonstrated the capabilities of HMDs. Knowledge gained from this system serves as a baseline for the development of future HMDs, e.g., AIHS (HGU-56/P) and LHX. This knowledge is applicable to fixed-, as well as rotary-wing aircraft. However, the design of the HMD is highly dependent on the mission and must be tailored to meet the information requirements of the pilot.

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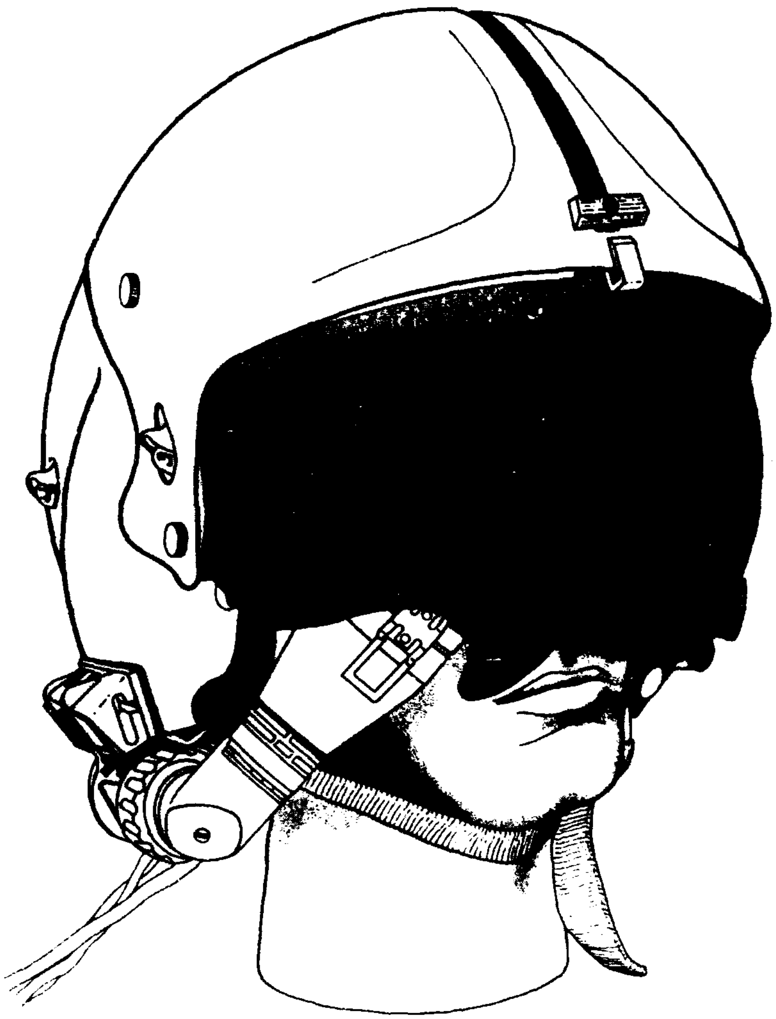

Figure 1. The Integrated Helmet and Display Sighting System (IHADSS) helmet.

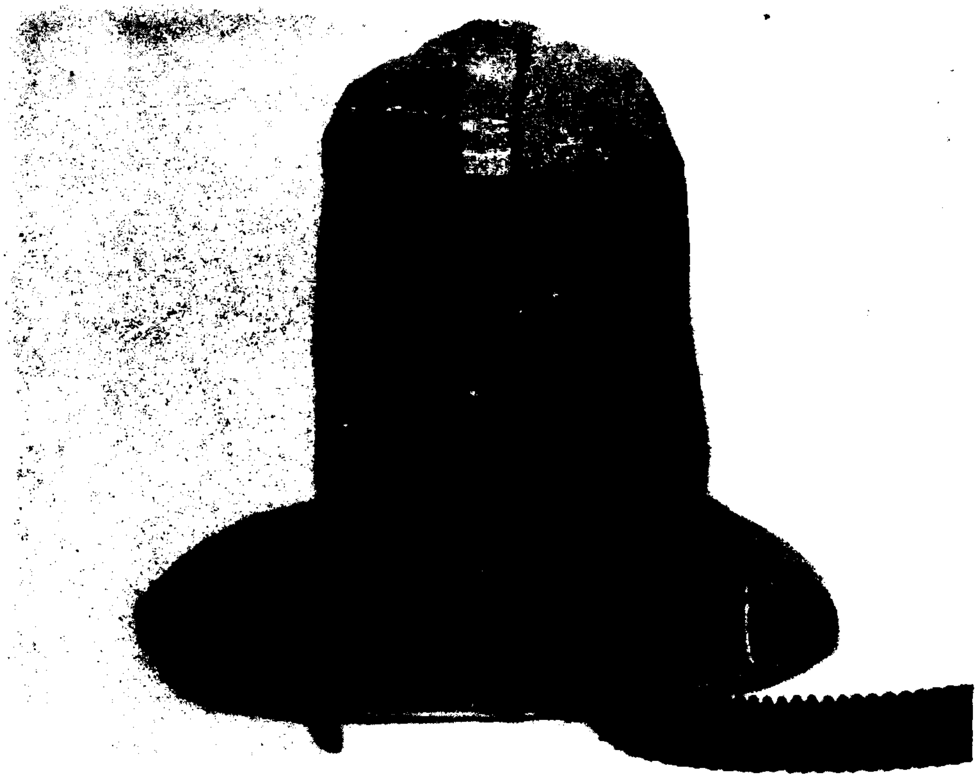

Figure 2. The M-43 chemical protective mask.